JC03 Rec'd PCT/PTO 26 APR 2001

Form PTO-1390 (REV 10-97)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
020352-000100US

U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5)
09/830496

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/IL99/00566	26 October 1999	26 October 1998

TITLE OF INVENTION
GAS LASER

APPLICANT(S) FOR DO/EO/US
Oded Anner, Shlomo Turgeman, and Haim Mukatel

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States receiving Office (RO/US)
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments as to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary examination Report under PCT Article 36 (35 U.S.C. 371(c)(5))

Items 11. to 16. below, concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: A copy of the International Search Report, and the International Preliminary Examination Report

JC18 Rec'd PCT/PTO 2 6 APR 2001

[AP]PLICATION NO. (If known, see 37 C.F.R. 1.5) 09/830496	INTERNATIONAL APPLICATION NO. PCT/IL99/00566	ATTORNEY'S DOCKET NUMBER 020352-000100US

17. ☒ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO 840.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) 670.00 No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2) 760.00 Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO 970.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) 96.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$ 840.00**	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	**$**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	36-20=	16	x $18.00	**$ 288.00**	
Independent Claims	4-3=	1	x $80.00	**$ 80.00**	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $260.00	**$**	
TOTAL OF ABOVE CALCULATIONS =				**$ 1208.00**	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 C.F.R. 1.9, 1.27, 1.28).				**$**	
SUBTOTAL =				**$**	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)). +				**$**	
TOTAL NATIONAL FEE =				**$ 1208.00**	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). $40.00 per property +				**$**	
TOTAL FEES ENCLOSED =				**$ 1208.00**	
				Amount to be refunded:	**$**
				charged	**$ 1208.00**

a. ☐ A check in the amount of $______ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 20-1430 in the amount of $ 1208.00 to cover the above fees.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 20-1430. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
Darin J. Gibby
Townsend and Townsend and Crew LLP
Two Embarcadero Center, 8th Floor
San Francisco, CA 94111

SIGNATURE

Darin J. Gibby
NAME

38,464
REGISTRATION NUMBER

Docket No. 020352-000100US

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(c)) - SMALL BUSINESS CONCERN

Applicant or Patentee: Oded Anner et al.
Application or Patent No.: 09/830,496
Filed or Issued: April 26, 2001
Title: GAS LASER

I hereby declare that I am:

[ ] the owner of the small business concern identified below:
[ ] an official of the small business concern empowered to act on behalf of the concern identified below.

Name of Small Business Concern: Lightlase Ltd.
Address of Small Business Concern:

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.12, and reproduced in 37 CFR 1 9(d), for purposes of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention, entitled GAS LASER by inventors Oded Anner, Shlomo Turgeman and Haim Mukatel described in:

[ ] the specification filed herewith;
[X] Application No. 09/830,496, filed April 26, 2001;
[ ] Patent No. ______, issued ______.

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights in the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern that would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

*NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

Name:
Address:

[ ] Individual [ ] Small Business Concern [ ] Nonprofit Organization

Name:
Address:

[ ] Individual [ ] Small Business Concern [ ] Nonprofit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Name of Person Signing: Oded Aner | Shlomo Turjeman | Haim Mukatel
Title of Person if Other than Owner: Chief Scientist | C.E.O.
Address of Person Signing: 9 NAHLIEL St. KFAR SAVA ISRAEL | 32 TIZMORET St. Rishon Le Zion ISRAEL | 4 HAARGAMAN St NES ZIONA ISRAEL

Signature: LightLase LTD. Date 17/6/01

DE 7041822 v1

PATENT
Attorney Docket No.: 020352-000100US
Client Reference No.: 42183

"Express Mail" Label No. EL801720592US
Date of Deposit April 26, 2001

I hereby certify that this is being deposited with the United States Postal Service "Express Mail Post Office to Address" service under 37 CFR 1.10 on the date indicated above and is addressed to:

Box PCT
Assistant Commissioner for Patents
Washington, D.C. 20231
By: Connie Larion

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:	Examiner:
Oded Anner et al.	Art Unit:
International Appl No. PCT/IL99/00566	PRELIMINARY AMENDMENT
International Filing Date:October 26, 1999	
For: GAS LASER	

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination of the above-referenced application, please enter the following amendments and remarks.

IN THE CLAIMS:

1. A gas laser comprising:

an annular optical cavity defined by a pair of coaxial spaced electrodes which produces an annular coherent beam of a first diameter and a first thickness;

a mirror structure located at one end of the annular optical cavity and including:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus a beam reflected by said first mirror surface to a location located interiorly of said pair of coaxial spaced electrodes;

a third mirror surface located at an opposite end of the annular optical cavity; and an output coupler operative to receive, reflect and transmit a beam reflected by said second mirror surface.

2. A laser according to claim 1 and wherein said first mirror surface is an off-axis parabolic rotationally symmetric surface.

3. (Amended) A laser according to claim 1 and wherein said second mirror surface is art off-axis ellipsoidal rotationally symmetric surface.

4. (Amended) A gas laser according to claim 1 and wherein:

said annular optical cavity is defined by inner and outer coaxial spaced electrodes which produces an annular coherent beam; and

said gas laser also comprises an RF power supply coupled to said outer electrode at at least one location symmetrical with respect to the length thereof.

5. A gas laser according to claim 4 and wherein the inner electrode is grounded.

6. (Amended) A gas laser according to claim 4 and comprising a grounded structure surrounding the annular optical cavity.

7. A gas laser according to claim 6 and wherein first and second ends of said outer electrode are coupled to said grounded structure via a plurality of induction coils.

8. A gas laser according to claim 4 and wherein said at least one location is a location centered with respect to the length of said outer electrode.

9. (Amended) A gas laser according to claim 1 and wherein said mirror structure is grounded.

10. A gas laser comprising:

an annular optical cavity defined by inner and outer coaxial spaced electrodes which produces an annular coherent bean; and

an RF power supply coupled to said outer electrode at at least one location symmetrical with respect to the length thereof.

11. A gas laser according to claim 10 and wherein the inner electrode is grounded.

12. (Amended) A gas laser according to claim 10 and comprising a grounded structure surrounding the annular optical cavity.

13. A gas laser according to claim 12 and wherein first and second ends of said outer electrode are coupled to said grounded structure via a plurality of induction coils.

14. A gas laser according to claim 10 and wherein said at least one location is a location centered with respect to the length of said outer electrode.

15. (Amended) A gas laser according to claim 10 and also comprising:

a grounded structure surrounding the annular optical cavity and including first and second portions having precisely formed first and second mating surfaces,

said first portion having machined thereon a first mirror structure located at one end of the annular optical cavity; and

said second portion having machined thereon a second mirror structure located at one end of the annular optical cavity.

16. A gas laser according to claim 15 and wherein said first mating surface and said first mirror structure are machined together so as to ensure desired alignment therebetween.

17. (Amended) A gas laser according to claim 15 and wherein said second mating surface and said second mirror structure are machined together so as to ensure desired alignment therebetween.

18. (Amended) A gas laser according to claim 15 and wherein said first mirror structure comprises:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus an annular beam reflected by said first mirror surface to a location located interior of said pair of coaxial spaced electrodes; and

a spatial filter disposed at said location located interior of said pair of coaxial spaced electrodes.

19. A gas laser according to claim 18 and wherein said second mirror structure comprises:

a third mirror surface located at an opposite end of the annular optical cavity.

20. (Amended) A gas laser according to claim 15 and also comprising an output coupler.

21. A gas laser comprising:

an annular optical cavity defined by inner and outer coaxial spaced electrodes which produces an annular coherent bean;

a grounded structure surrounding the annular optical cavity and including first and second portions having precisely formed first and second mating surfaces,

said first portion having machined thereon a. first mirror structure located at one end of the annular optical cavity; and

said second portion having machined thereon a second mirror structure located at one end of the annular optical cavity.

22. A gas laser according to claim 21 and wherein said first mating surface and said first mirror structure are machined together so as to ensure desired alignment therebetween.

23. (Amended) A gas laser according to claim 21 and wherein said second mating surface and said second mirror structure are machined together so as to ensure desired alignment therebetween.

24. (Amended) A gas laser according to claim 21 and wherein said first mirror structure comprises:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus an annular beam reflected by said first mirror surface to a location located interior of said pair of coaxial spaced electrodes; and

a spatial filter disposed at said location located interior of said pair of coaxial spaced electrodes.

25. A gas laser according to claim 24 and wherein said second mirror structure comprises:

a third mirror surface located at an opposite end of the annular optical cavity.

26. (Amended) A gas laser according to claim 19 and also comprising an output coupler.

27. A gas laser comprising:

an enclosure;

an annular optical cavity defined by inner and outer coaxial spaced electrodes disposed within said enclosure and which produces art annular coherent beam; and

a plurality of RF power supplies mounted onto said enclosure and coupled to said outer electrode at multiple locations thereon distributed along the length and circumference thereof, thereby to provide generally homogeneous power and voltage distribution throughout said cavity.

28. A gas laser according to claim 27 and wherein the inner electrode is grounded.

29. (Amended) A gas laser according to claim 27 and comprising a grounded structure surrounding the annular optical cavity.

30. A gas laser according to claim 29 and wherein first and second ends of said outer electrode are coupled to said grounded structure via a plurality of induction coils.

31. (Amended) A gas laser according, to claim 27 and wherein said second mating surface and said second mirror structure are machined together so as to ensure desired alignment therebetween.

32. A gas laser according to claim 31 and wherein said first mating surface and said first mirror structure are machined together so as to ensure desired alignment therebetween.

33. (Amended) A gas laser according to claim 30 and wherein said second mating surface and said second mirror structure are machined together so as to ensure desired alignment therebetween.

34. (Amended) A gas laser according to claim 30 and wherein said first mirror structure comprises:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus an annular beam reflected by said first mirror surface to a location located interior of said pair of coaxial spaced electrodes; and

a spatial filter disposed at said location located interior of said pair of coaxial spaced electrodes.

35. A gas laser according to claim 34 and wherein said second mirror structure comprises:
a third mirror surface located at an opposite end of the annular optical cavity.

36. A gas laser according to claim 31 and also comprising an output coupler.

REMARKS

Claims 3, 4, 6, 9, 12, 15, 17, 18, 20, 23, 24, 26, 29, 31, 33, 34 and 36 have been amended. Examination of the application, as amended, is respectfully requested. If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at 303-571-4000.

Respectfully submitted,

Darin J. Gibby
Reg. No. 38,464

TOWNSEND and TOWNSEND and CREW LLP
Two Embarcadero Center, 8th Floor
San Francisco, California 94111-3834
Tel: (415) 576-0200
Fax: (415) 576-0300

DE 7038839 v1

Marked Claims Pursuant to 37 CFR §1.121(c)

1. A gas laser comprising:

an annular optical cavity defined by a pair of coaxial spaced electrodes which produces an annular coherent beam of a first diameter and a first thickness;

a mirror structure located at one end of the annular optical cavity and including:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus a beam reflected by said first mirror surface to a location located interiorly of said pair of coaxial spaced electrodes;

a third mirror surface located at an opposite end of the annular optical cavity; and an output coupler operative to receive, reflect and transmit a beam reflected by said second mirror surface.

2. A laser according to claim 1 and wherein said first mirror surface is an off-axis parabolic rotationally symmetric surface.

3. (Amended) A laser according to claim 1 **[or claim 2]** and wherein said second mirror surface is art off-axis ellipsoidal rotationally symmetric surface.

4. (Amended) A gas laser according to claim 1 **[any of claims 1 - 3]** and wherein:

said annular optical cavity is defined by inner and outer coaxial spaced electrodes which produces an annular coherent beam; and

said gas laser also comprises an RF power supply coupled to said outer electrode at at least one location symmetrical with respect to the length thereof.

5. A gas laser according to claim 4 and wherein the inner electrode is grounded.

6. (Amended) A gas laser according to claim 4 **[or claim 5]** and comprising a grounded structure surrounding the annular optical cavity.

7. A gas laser according to claim 6 and wherein first and second ends of said outer electrode are coupled to said grounded structure via a plurality of induction coils.

8. A gas laser according to claim 4 and wherein said at least one location is a location centered with respect to the length of said outer electrode.

9. (Amended) A gas laser according to <u>claim 1</u> **[any of the preceding claims]** and wherein said mirror structure is grounded.

10. A gas laser comprising:

an annular optical cavity defined by inner and outer coaxial spaced electrodes which produces an annular coherent bean; and

an RF power supply coupled to said outer electrode at at least one location symmetrical with respect to the length thereof.

11. A gas laser according to claim 10 and wherein the inner electrode is grounded.

12. (Amended) A gas laser according to claim 10 **[or claim 11]** and comprising a grounded structure surrounding the annular optical cavity.

13. A gas laser according to claim 12 and wherein first and second ends of said outer electrode are coupled to said grounded structure via a plurality of induction coils.

14. A gas laser according to claim 10 and wherein said at least one location is a location centered with respect to the length of said outer electrode.

15. (Amended) A gas laser according to <u>claim 10</u> **[any of claims 10 - 14]** and also comprising:

a grounded structure surrounding the annular optical cavity and including first and second portions having precisely formed first and second mating surfaces,

said first portion having machined thereon a first mirror structure located at one end of the annular optical cavity; and

said second portion having machined thereon a second mirror structure located at one end of the annular optical cavity.

16. A gas laser according to claim 15 and wherein said first mating surface and said first mirror structure are machined together so as to ensure desired alignment therebetween.

17. (Amended) A gas laser according to claim 15 **[or claim 16]** and wherein said second mating surface and said second mirror structure are machined together so as to ensure desired alignment therebetween.

18. (Amended) A gas laser according to claim 15 **[any of claims 15 — 17]** and wherein said first mirror structure comprises:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus an annular beam reflected by said first mirror surface to a location located interior of said pair of coaxial spaced electrodes; and

a spatial filter disposed at said location located interior of said pair of coaxial spaced electrodes.

19. A gas laser according to claim 18 and wherein said second mirror structure comprises:

a third mirror surface located at an opposite end of the annular optical cavity.

20. (Amended) A gas laser according to claim 15 **[any of claims 15 — 19]** and also comprising an output coupler.

21. A gas laser comprising:

an annular optical cavity defined by inner and outer coaxial spaced electrodes which produces an annular coherent bean;

a grounded structure surrounding the annular optical cavity and including first and second portions having precisely formed first and second mating surfaces,

said first portion having machined thereon a. first mirror structure located at one end of the annular optical cavity; and

said second portion having machined thereon a second mirror structure located at one end of the annular optical cavity.

22. A gas laser according to claim 21 and wherein said first mating surface and said first mirror structure are machined together so as to ensure desired alignment therebetween.

23. (Amended) A gas laser according to claim 21 **[or claim 22]** and wherein said second mating surface and said second mirror structure are machined together so as to ensure desired alignment therebetween.

24. (Amended) A gas laser according to <u>claim 21</u> **[any of claims 21 - 23]** and wherein said first mirror structure comprises:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus an annular beam reflected by said first mirror surface to a location located interior of said pair of coaxial spaced electrodes; and

a spatial filter disposed at said location located interior of said pair of coaxial spaced electrodes.

25. A gas laser according to claim 24 and wherein said second mirror structure comprises:

a third mirror surface located at an opposite end of the annular optical cavity.

26. (Amended) A gas laser according to <u>claim 19</u> **[any of claims 19 - 23]** and also comprising an output coupler.

27. A gas laser comprising:

an enclosure;

an annular optical cavity defined by inner and outer coaxial spaced electrodes disposed within said enclosure and which produces art annular coherent beam; and

a plurality of RF power supplies mounted onto said enclosure and coupled to said outer electrode at multiple locations thereon distributed along the length and circumference thereof, thereby to provide generally homogeneous power and voltage distribution throughout said cavity.

28. A gas laser according to claim 27 and wherein the inner electrode is grounded.

29. (Amended) A gas laser according to claim 27 **[or claim 28]** and comprising a grounded structure surrounding the annular optical cavity.

30. A gas laser according to claim 29 and wherein first and second ends of said outer electrode are coupled to said grounded structure via a plurality of induction coils.

31. (Amended) A gas laser according, to claim 27 **[any of claims 27 — 30]** and also comprising:

a grounded structure surrounding the annular optical cavity and including first and second portions having precisely formed first and second mating surfaces,

said first portion having machined thereon a first mirror structure located at one end of the annular optical cavity; and

said second portion having machined thereon a second mirror structure located at one end of the annular optical cavity.

32. A gas laser according to claim 31 and wherein said first mating surface and said first mirror structure are machined together so as to ensure desired alignment therebetween.

33. (Amended) A gas laser according to claim 30 **[or claim 31]** and wherein said second mating surface and said second mirror structure are machined together so as to ensure desired alignment therebetween.

34. (Amended) A gas laser according to claim 30 **[any of claims 30 - 33]** and wherein said first mirror structure comprises:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus an annular beam reflected by said first mirror surface to a location located interior of said pair of coaxial spaced electrodes; and

a spatial filter disposed at said location located interior of said pair of coaxial spaced electrodes.

35. A gas laser according to claim 34 and wherein said second mirror structure comprises:

a third mirror surface located at an opposite end of the annular optical cavity.

36. (Amended) A gas laser according to claim 31 **[any of claims 31 - 35]** and also comprising an output coupler.

GAS LASER

FIELD OF THE INVENTION

The present invention relates to lasers generally and more particularly to gas lasers.

BACKGROUND OF THE INVENTION

Various types of gas lasers are known in the art. RF excited diffusion cooled gas lasers having extended area thin gap electrodes are commercially available in both slab and annular configurations. Both the slab and the annular configurations require high frequency RF excitation in the typical range of 60 - 150 MHz in order to achieve uniform arc-free discharge. In lasers of this type, as contrasted from other types of gas lasers, power scales to electrode area and not to electrode length, thus enabling relatively compact lasers to be constructed.

Basic configurations of both slab and annular RF excited diffusion cooled gas lasers produced generally unusable beam shapes. The slab configuration produces a beam having an elongate thin line sectional structure, while the annular laser produces a beam having a thin annular sectional structure.

RF excited diffusion cooled gas lasers of both of the above configurations display undesirable voltage variation along the electrodes due to transmission line plasma phenomena. This voltage variation leads to unequal values of the E/N parameter along the length of the electrode and thus to reduced efficiency of the resonator. In slab electrodes, this difficulty is at least partially overcome by placing a plurality of inductors along the slab, thus reducing the voltage variations to a few

percent.

A general problem encountered in RF excited diffusion cooled gas lasers is alignment of optics with respect to each other and with respect to the thin gap electrodes. A general problem in RF excited diffusion cooled gas lasers having an annular configuration is undesirable creation of higher order modes in the lasing process which are difficult to filter out and which significantly degrade the quality of the output beam.

The following U.S. Patents are believed to represent the state of the art: U.S. Patent 4,847,852 which describes an RF excited diffusion cooled gas laser of the annular configuration; U.S. Patent 5,123,028 which describes an RF excited diffusion cooled gas laser of the slab configuration; and U.S. Patent 5,099,492 which describes a RF excited gas laser of the annular configuration.

SUMMARY OF THE INVENTION

The present invention seeks to provide an improved gas laser which overcomes limitations of the prior art.

There is thus provided in accordance with a preferred embodiment of the present invention a gas laser including:

an annular optical cavity defined by a pair of coaxial spaced electrodes which produces an annular coherent beam of a first diameter and a first thickness;

a mirror structure located at one end of the annular optical cavity and including:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from the first diameter and to expand the thickness of the annular coherent beam from the first thickness;

a second mirror surface which is operative to focus a beam reflected by the first mirror surface to a location located interiorly of the pair of coaxial spaced electrodes;

a third mirror surface located at an opposite end of the annular optical cavity; and

an output coupler operative to receive, reflect and transmit a beam reflected by the second mirror surface.

There is also provided in accordance with a preferred embodiment of the present invention a gas laser including:

an annular optical cavity defined by inner and outer coaxial spaced electrodes which produces an annular coherent beam; and

an RF power supply coupled to the outer electrode at at

least one location symmetrical with respect to the length thereof.

There is additionally provided in accordance with a preferred embodiment of the present invention a gas laser including an enclosure, an annular optical cavity defined by inner and outer coaxial spaced electrodes disposed within the enclosure and which produces an annular coherent beam and a plurality of RF power supplies mounted onto the enclosure and coupled to the outer electrode at multiple locations thereon distributed along the length and circumference thereof, thereby to provide generally homogeneous power and voltage distribution throughout the cavity.

There is additionally provided in accordance with an embodiment of the present invention, a gas laser including:

an annular optical cavity defined by inner and outer coaxial spaced electrodes which produces an annular coherent beam;

a grounded structure surrounding the annular optical cavity and including first and second portions having precisely formed first and second mating surfaces,

the first portion having machined thereon a first mirror structure located at one end of the annular optical cavity; and

the second portion having machined thereon a second mirror structure located at one end of the annular optical cavity.

In accordance with an embodiment of the present invention, the first mirror surface is an off-axis parabolic rotation-

ally symmetric surface.

In accordance with an embodiment of the present invention, the second mirror surface is an off-axis ellipsoidal rotationally symmetric surface.

Preferably, the annular optical cavity is defined by inner and outer coaxial spaced electrodes which produces an annular coherent beam and the gas laser also includes an RF power supply coupled to the outer electrode at at least one location symmetrical with respect to the length thereof.

Preferably, the inner electrode is grounded and there is provided a grounded structure surrounding the annular optical cavity.

In accordance with an embodiment of the present invention, first and second ends of the outer electrode are coupled to the grounded structure via a plurality of induction coils.

Preferably, the at least one location is a location centered with respect to the length of the outer electrode.

In accordance with an embodiment of the present invention, the mirror structure is grounded.

In accordance with an embodiment of the present invention, there is provided a grounded structure surrounding the annular optical cavity and including first and second portions having precisely formed first and second mating surfaces,

the first portion having machined thereon a first mirror structure located at one end of the annular optical cavity; and

the second portion having machined thereon a second

mirror structure located at one end of the annular optical cavity.

Preferably, the first mating surface and the first mirror structure are machined together so as to ensure desired alignment therebetween.

Preferably, the second mating surface and the second mirror structure are machined together so as to ensure desired alignment therebetween.

In accordance with an embodiment of the present invention, the first mirror structure includes:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from the first diameter and to expand the thickness of the annular coherent beam from the first thickness;

a second mirror surface which is operative to focus an annular beam reflected by the first mirror surface to a location located interior of the pair of coaxial spaced electrodes; and

a spatial filter disposed at the location located interior of the pair of coaxial spaced electrodes.

Preferably, the second mirror structure includes a third mirror surface located at an opposite end of the annular optical cavity.

In accordance with an embodiment of the present invention, the gas laser also includes an output coupler.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1 is a simplified sectional illustration of an RF excited diffusion cooled gas laser of an annular configuration constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 2 is a simplified sectional illustration showing the optical structure of the RF excited diffusion cooled gas laser of Fig. 1;

Fig. 3A is a sectional illustration taken along lines A - A in Fig. 2, showing the beam configuration along lines A - A;

Fig. 3B is a sectional illustration taken along lines B - B in Fig. 2, showing the beam configuration along lines B - B;

Fig. 3C is a sectional illustration taken along lines C - C in Fig. 2, showing the beam configuration along lines C - C;

Fig. 3D is a sectional illustration taken along lines D - D in Fig. 2, showing the beam configuration along lines D - D;

Fig. 3E is a sectional illustration taken along lines E - E in Fig. 2, showing the beam configuration along lines E - E;

Fig. 3F is a sectional illustration taken along lines F - F in Fig. 2, showing the beam configuration along lines F - F;

Fig. 3G is a sectional illustration taken along lines G - G in Fig. 2, showing the beam configuration along lines G - G;

Fig. 3H is a sectional illustration taken along lines H - H in Fig. 2, showing the beam configuration along lines H - H;

Fig. 3I is a sectional illustration taken along lines I - I in Fig. 2, showing the beam configuration along lines I - I;

Fig. 3J is a sectional illustration taken along lines J - J in Fig. 2, showing the beam configuration along lines J - J;

Fig. 3K is a sectional illustration taken along lines K - K in Fig. 2, showing the beam configuration along lines K - K;

Fig. 4 is a simplified sectional illustration showing the aspherical surfaces of the optical structure of the laser of Figs. 1 and 2;

Fig. 5 is a simplified illustration of the RF electrical structure of the laser of Fig. 1;

Fig. 6 is a simplified illustration of the opto-mechanical structure of the laser of Fig. 1; and

Fig. 7 is a simplified illustration of the RF electrical structure of an alternative embodiment of the laser of Fig. 1.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is now made to Fig. 1, which is a simplified sectional illustration of an RF excited diffusion cooled gas laser 100 of an annular configuration constructed and operative in accordance with a preferred embodiment of the present invention. The laser of Fig. 1 comprises first and second enclosure elements 102 and 104, typically formed of aluminum, and an output coupler assembly 106.

Output coupler assembly 106 is mounted over an aperture 108 formed in an end of enclosure element 104. The output coupler assembly 106 preferably comprises an annular spacer element 110 and an mirror housing element 112 which secures an output coupler mirror 114 against spacer element 110. Output coupler mirror 114 may be any suitable output coupler mirror. When laser 100 is a CO2 laser, the output coupler mirror 114 is preferably a ZnSe mirror.

First and second enclosure elements 102 and 104 are joined together as shown in Fig. 1 to define an enclosure 116 in which are mounted respective coaxial inner and outer generally circular cylindrical electrodes 120 and 122, which are centered about a longitudinal axis 123. Inner electrode 120 is typically formed of aluminum and has a circular cylindrical configuration. It is mounted within enclosure 116 at one end by means of a cylindrical mounting element 124 which is fixed to an interior cylindrical surface 126 of electrode 120 and is tightly secured against corresponding interior surfaces 128 and 130 of enclosure element 104. Preferably an annular RF contact spring 134 is interposed between an end surface 136 of mounting element 124 and

a corresponding interior surface 138 of enclosure element 104.

Inner electrode 120 is preferably mounted at its opposite end to the interior of enclosure element 102 by means of a plurality of spider struts 140, typically three in number. Each spider strut 140 includes a first end 142 fixed to an end surface 144 of electrode 120, a central knife-like portion 146 and a second end 148 which is tightly seated in a cylindrical recess 150 formed in an interior surface of enclosure element 102. Preferably an annular RF contact spring 154 is interposed between an end surface 156 of the second end 148 of each spider strut and a corresponding interior facing surface 158 of recess 150.

Outer electrode 122 preferably comprises an integrally formed generally circular cylinder including a generally cylindrical inner recess 170 bounded by cylinder ends 172 and 174 having respective outwardly facing surfaces 176 and 178. Outer electrode 122 is preferably fixedly mounted onto respective interior surfaces 180 and 182 of enclosure elements 102 and 104 respectively by means of respective ceramic annuli 184 and 186 respectively. A generally cylindrical, electrically insulative, cover element 190 surrounds outer electrode 122.

Recess 170 defines a coolant circulation chamber, which preferably communicates with a coolant fluid supply (not shown) and a coolant fluid drain (not shown) via fluid communication conduits 194 and 195. The inner electrode 120 is also cooled preferably by cooling fluid passing through a channel 196 extending therethough via conduits 197 and 198.

A plurality of induction termination coils 199 are

formed in bores 200 located at locations distributed about the circumference of ceramic annuli 184 and 186.

An RF input connection 202 is provided at the center of the outer electrode 122 and comprises a metal rod 204 preferably surrounded by an insulator 206.

A cylindrical discharge gap 210 is defined between the inner and outer electrodes 120 and 122 in the region between ceramic annuli 184 and 186.

An inner facing surface of enclosure element 102 is preferably configured to define a first mirror surface 220, which is operative to decrease the diameter of an annular coherent beam formed in the discharge gap 210 from a first diameter and to expand the thickness of the annular coherent beam from a first thickness corresponding to the thickness of the discharge gap 210.

The inner facing surface of enclosure element 102 is also preferably configured to define a second mirror surface 222 which is centered about longitudinal axis 123. Second mirror surface 222 is operative to focus an annular beam reflected by the first mirror surface 220 to a location 224 located interior of the pair of coaxial spaced electrodes 120 and 122 and along longitudinal axis 123.

An inner facing surface of enclosure element 104 is preferably configured to define a third mirror surface 230, which, together with the first and second mirror surfaces 220 and 222 and the output coupler mirror 114 defines a laser resonator.

A spatial filter 240 is preferably located within inner electrode 120 at location 224.

Reference is now made to Fig. 2, which is a simplified sectional illustration showing the optical structure of the RF excited diffusion cooled gas laser of Fig. 1. It is seen that first mirror surface 220, which is preferably an off-axis paraboloidal rotationally symmetric surface, is operative to decrease the diameter of an annular coherent beam 250 from a first diameter corresponding to the diameter of discharge gap 210 (Fig. 1) and to expand the thickness of the annular coherent beam 220 from a first thickness T corresponding to the thickness of discharge gap 210 (Fig. 1). Thickness T is illustrated in Fig. 3A.

First mirror surface 220 is thus operative to provide a beam 252, a sectional illustration of which appears in Fig. 3B, which passes through a ring focus at a location 254. The cross section of beam 252 at location 254 is illustrated in Fig. 3C. Downstream of location 254, beam 252 expands sequentially as shown in the sectional illustrations of Figs. 3D and 3E.

Second mirror surface 222 is typically an off-axis, ellipsoidal rotationally symmetric surface and is operative to focus beam 252 reflected by first mirror surface 220 to location 224 located interiorly of coaxial spaced electrodes 120 and 122. Fig. 3F shows the beam as it is impinges on second mirror surface 222. The beam reflected by second mirror surface 222, designated by reference numeral 260, is a generally solid beam which is sequentially focussed, as illustrated in the sectional illustrations of Figs. 3G, 3H and 3I. Fig. 3I shows beam 260 at location 224.

Downstream of location 224, beam 260 sequentially

expands as illustrated in the sectional illustrations of Figs. 3J and 3K until it impinges on surface 270 of output coupler 114.

Third mirror surface 230, located at an opposite end of the annular optical cavity defined by discharge gap 210 is a flat mirror which reflects beam 250 back into discharge gap 210.

Output coupler 114 is operative to receive, reflect and transmit a beam 260 reflected by the second mirror surface 222. Output coupler 114 defines a first partially reflective surface 270 which is spherical and has a radius of curvature equal to the distance between the surface 270 and location 224 and is thus operative to reflect part of the beam 260 back to location 224. The remainder of beam 260, which is not reflected by surface 270 is collimated by a second surface 272 of output coupler 114 and exits as useful laser power.

Spatial filter 240, located at location 224 is operative to substantially prevent occurrence of high order modes, thus enabling the laser to operate in the lowest order mode.

It is a particular feature of the present invention described hereinabove that the mirror surfaces 220 and 222 are constructed such that location 254 lies at the common focus of both mirror surfaces 220 and 222. As seen in Fig. 4, mirror surface 220 is based on an off-axis section of a parabola 280. This off-axis section is rotated about axis 123 to define the annular mirror surface 220.

Similarly mirror surface 222 is based on an off-axis section of an ellipse 282. This off-axis section is rotated about axis 123 to define the mirror surface 222. Thus, it is appreciated that location 254 is located both at the focus of the parabola

280 and at one of the foci of the ellipse 282. Location 224 is located at the second focus of ellipse 282.

This structure ensures that substantially each light ray passing through location 254 arrives at location 224. In this way, an annular beam is effective transformed to a solid conical beam.

It is a particular feature of the invention that by varying the design of the laser to selectably position location 254, one may determine the diameter of the beam reflected from surface 222.

Mirrors 220 and 222 serve three important functions: They transform an annular beam into a solid beam of round cross section; they serve as intracavity expansion optics and they couple rear mirror 230 and output coupler 114.

Reference is now made to Fig. 5, which is a simplified illustration of the RF electrical structure of the laser of Fig. 1. As seen in Fig. 5, an annular optical cavity is defined by discharge gap 210 between by inner and outer coaxial spaced electrodes 120 and 122. An RF power supply 300 is coupled to the outer electrode 122 at at least one location 302 symmetrical with respect to the length of outer electrode 122. The RF power supply 300 is typically coupled to outer electrode 122 at location 302 via a conventional RF matching unit 304 and via RF input connection 202 (Fig. 1). The inner electrode 120 is grounded, preferably via enclosure elements 102 and 104.

Preferably RF power supply 300 is grounded and provides grounding of enclosure elements 102 and 104 via RF matching unit

304.

In accordance with a preferred embodiment of the present invention, first and second ends 310 and 320 of the outer electrode 122 are coupled to respective grounded enclosure elements 102 and 104 via a plurality of induction coils 199.

The provision of induction coils 199 is operative to reduce undesirable voltage variation along the electrodes due to transmission line plasma phenomena.

In accordance with a preferred embodiment of the present invention, the outer electrode 122 is insulated from ground by ceramic annuli 184 and 186 and by cover element 190, which is an insulator preferably formed of a polymer. This structure effective restricts discharge to the region bounded by ceramic annuli 184 and 186. Beyond this region, the thin gap cavity 210 extends, typically 15 - 25 mm, and thus the hot excited gas reaching the extension of cavity 210 is effectively cooled and quenched by diffusion to the walls of cavity 210. Thus only relatively cold and unexcited gas exits cavity 210, thereby preventing premature degradation of mirror surfaces 220 and 230, which are located a relatively short distance from the apertures of cavity 210.

It is a particular feature of the embodiment of Fig. 5 that the mirror surfaces 220 and 230 may be placed at a relatively short distance from the respective ends of cavity 210, typically less than 10 mm. This relatively short distance enables the wavefront exiting the cavity 210 to be maintained generally planar, providing optimal performance of the focusing optics 220, 222 and 270 and minimizing energy losses due to beam divergence.

Reference is now made to Fig. 6, which is a simplified illustration of the opto-mechanical structure of the laser of Fig. 1. It is seen that mirror surfaces 220 and 222 are preferably integrally formed with enclosure element 102, as by diamond turning. Similarly mirror surface 230 is preferably integrally formed with enclosure element 104, as by diamond turning.

Preferably, respective mating surfaces 350 and 352 of enclosure elements 102 and 104 at their junction, indicated here by reference numeral 354 are flat diamond turned surfaces. Preferably enclosure elements 102 and 104 are clamped together.

It is a particular feature of the invention that joined enclosure elements define an integral mechanical, optical and electrical structure for the laser. Inasmuch as surfaces 350, 220 and 222 may all be machined in a single operation, and similarly surfaces 352 and 230 may be machined in a separate single operation, mutual alignment of surfaces 220, 222 and 230 may be realized by mutual attachment of mating surfaces 350 and 352 at junction 354. This greatly simplifies the structure and assembly of the laser and significantly lowers its cost.

It is appreciated that the laser may be formed with multiple mating surfaces.

It is a particular feature of the present invention that the laser, with the exception of the output coupler, is formed entirely of aluminum. This enables thermal effects to be readily minimized.

Reference is now made to Fig. 7, which is a simplified illustration of the RF electrical structure of an alternative

embodiment of the laser of Fig. 1. As seen in Fig. 7, similarly to the embodiment of Figs. 1 - 6, an annular optical cavity is defined by discharge gap 210 between by inner and outer coaxial spaced electrodes 120 and 122.

As distinct from the embodiment of Figs. 1 - 6, in the embodiment of Fig. 7, an RF is coupled to the outer electrode 122 via multiple discrete solid state RF power supply units 402. Suitable solid state RF power supply units are commercially available from various suppliers including, for example, Delta Sigma Inc. of Riverside, California, U.S.A..

Solid state RF power supply units 402 are preferably mounted exteriorly of first and second enclosure elements 102 and 104 (Figs. 1 & 5) and provide power outputs at multiple locations at the outer electrode 122 (Figs. 1 & 5) as shown in Fig. 7, thereby to provide a generally homogeneous distribution of power and voltage along the length and circumference of the laser cavity.

A DC power supply 404 preferably supplies electrical power to the RF power supply units 402.

Preferably each RF power supply unit 402 is provided with a conventional RF matching unit 406 which outputs via an RF input connection 408.

As in the embodiment of Figs. 1 - 6, the inner electrode 120 is grounded, preferably via enclosure elements 102 and 104.

Preferably DC power supply 404 is grounded and provides grounding of enclosure elements 102 and 104 via RF power supply units 402.

In both the embodiments of Figs. 1 - 6 and Fig. 7, the provision of a plurality of induction coils 199 is optional.

As in the embodiment of Figs. 1 - 6, the outer electrode 122 is insulated from ground by ceramic annuli 184 and 186 and by cover element 190, which is an insulator preferably formed of a polymer. This structure effective restricts discharge to the region bounded by ceramic annuli 184 and 186. Beyond this region, the thin gap cavity 210 extends, typically 15 - 25 mm, and thus the hot excited gas reaching the extension of cavity 210 is effectively cooled and quenched by diffusion to the walls of cavity 210. Thus only relatively cold and unexcited gas exits cavity 210, thereby preventing premature degradation of mirror surfaces 220 and 230, which are located a relatively short distance from the apertures of cavity 210.

It is noted that the embodiments of Figs. 1 - 6 and of Fig. 7 provide alternative solutions to the problem of voltage variations leading to unequal values of the E/N parameter along the length of the electrode and thus to reduced efficiency of the resonator. The solution of Fig. 7 is applicable to slab lasers as well as to co-axial lasers.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the present invention includes also combinations and subcombinations of the various features described hereinabove as well as modifications and additions thereto as would occur to a person skilled in the art upon reading the foregoing description and which are not in

the prior art.

CLAIMS

1. A gas laser comprising:

an annular optical cavity defined by a pair of coaxial spaced electrodes which produces an annular coherent beam of a first diameter and a first thickness;

a mirror structure located at one end of the annular optical cavity and including:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus a beam reflected by said first mirror surface to a location located interiorly of said pair of coaxial spaced electrodes;

a third mirror surface located at an opposite end of the annular optical cavity; and

an output coupler operative to receive, reflect and transmit a beam reflected by said second mirror surface.

2. A laser according to claim 1 and wherein said first mirror surface is an off-axis parabolic rotationally symmetric surface.

3. A laser according to claim 1 or claim 2 and wherein said second mirror surface is an off-axis ellipsoidal rotationally symmetric surface.

4. A gas laser according to any of claims 1 - 3 and wherein:

said annular optical cavity is defined by inner and outer coaxial spaced electrodes which produces an annular coherent beam; and

said gas laser also comprises an RF power supply coupled to said outer electrode at at least one location symmetrical with respect to the length thereof.

5. A gas laser according to claim 4 and wherein the inner electrode is grounded.

6. A gas laser according to claim 4 or claim 5 and comprising a grounded structure surrounding the annular optical cavity.

7. A gas laser according to claim 6 and wherein first and second ends of said outer electrode are coupled to said grounded structure via a plurality of induction coils.

8. A gas laser according to claim 4 and wherein said at least one location is a location centered with respect to the length of said outer electrode.

9. A gas laser according to any of the preceding claims and wherein said mirror structure is grounded.

10. A gas laser comprising:

an annular optical cavity defined by inner and outer coaxial spaced electrodes which produces an annular coherent beam; and

an RF power supply coupled to said outer electrode at at least one location symmetrical with respect to the length thereof.

11. A gas laser according to claim 10 and wherein the inner electrode is grounded.

12. A gas laser according to claim 10 or claim 11 and comprising a grounded structure surrounding the annular optical cavity.

13. A gas laser according to claim 12 and wherein first and second ends of said outer electrode are coupled to said grounded structure via a plurality of induction coils.

14. A gas laser according to claim 10 and wherein said at least one location is a location centered with respect to the length of said outer electrode.

15. A gas laser according to any of claims 10 - 14 and also comprising:

a grounded structure surrounding the annular optical cavity and including first and second portions having precisely formed first and second mating surfaces,

said first portion having machined thereon a first mirror structure located at one end of the annular optical cavity; and

said second portion having machined thereon a second mirror structure located at one end of the annular optical cavity.

16. A gas laser according to claim 15 and wherein said first mating surface and said first mirror structure are machined together so as to ensure desired alignment therebetween.

17. A gas laser according to claim 15 or claim 16 and wherein said second mating surface and said second mirror structure are machined together so as to ensure desired alignment therebetween.

18. A gas laser according to any of claims 15 - 17 and wherein said first mirror structure comprises:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus an annular beam reflected by said first mirror surface to a location located interior of said pair of coaxial spaced electrodes; and

a spatial filter disposed at said location located interior of said pair of coaxial spaced electrodes.

19. A gas laser according to claim 18 and wherein said second mirror structure comprises:

a third mirror surface located at an opposite end of the annular optical cavity.

20. A gas laser according to any of claims 15 - 19 and also comprising an output coupler.

21. A gas laser comprising:

an annular optical cavity defined by inner and outer coaxial spaced electrodes which produces an annular coherent beam;

a grounded structure surrounding the annular optical cavity and including first and second portions having precisely formed first and second mating surfaces,

said first portion having machined thereon a first mirror structure located at one end of the annular optical cavity; and

said second portion having machined thereon a second

mirror structure located at one end of the annular optical cavity.

22. A gas laser according to claim 21 and wherein said first mating surface and said first mirror structure are machined together so as to ensure desired alignment therebetween.

23. A gas laser according to claim 21 or claim 22 and wherein said second mating surface and said second mirror structure are machined together so as to ensure desired alignment therebetween.

24. A gas laser according to any of claims 21 - 23 and wherein said first mirror structure comprises:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to focus an annular beam reflected by said first mirror surface to a location located interior of said pair of coaxial spaced electrodes; and

a spatial filter disposed at said location located interior of said pair of coaxial spaced electrodes.

25. A gas laser according to claim 24 and wherein said second mirror structure comprises:

a third mirror surface located at an opposite end of

the annular optical cavity.

26. A gas laser according to any of claims 19 - 23 and also comprising an output coupler.

27. A gas laser comprising:

an enclosure;

an annular optical cavity defined by inner and outer coaxial spaced electrodes disposed within said enclosure and which produces an annular coherent beam; and

a plurality of RF power supplies mounted onto said enclosure and coupled to said outer electrode at multiple locations thereon distributed along the length and circumference thereof, thereby to provide generally homogeneous power and voltage distribution throughout said cavity.

28. A gas laser according to claim 27 and wherein the inner electrode is grounded.

29. A gas laser according to claim 27 or claim 28 and comprising a grounded structure surrounding the annular optical cavity.

30. A gas laser according to claim 29 and wherein first and second ends of said outer electrode are coupled to said grounded structure via a plurality of induction coils.

31. A gas laser according to any of claims 27 - 30 and also

comprising:

a grounded structure surrounding the annular optical cavity and including first and second portions having precisely formed first and second mating surfaces,

said first portion having machined thereon a first mirror structure located at one end of the annular optical cavity; and

said second portion having machined thereon a second mirror structure located at one end of the annular optical cavity.

32. A gas laser according to claim 31 and wherein said first mating surface and said first mirror structure are machined together so as to ensure desired alignment therebetween.

33. A gas laser according to claim 30 or claim 31 and wherein said second mating surface and said second mirror structure are machined together so as to ensure desired alignment therebetween.

34. A gas laser according to any of claims 30 - 33 and wherein said first mirror structure comprises:

a first mirror surface which is operative to decrease the diameter of the annular coherent beam from said first diameter and to expand the thickness of the annular coherent beam from said first thickness;

a second mirror surface which is operative to

focus an annular beam reflected by said first mirror surface to a location located interior of said pair of coaxial spaced electrodes; and

a spatial filter disposed at said location located interior of said pair of coaxial spaced electrodes.

35. A gas laser according to claim 34 and wherein said second mirror structure comprises:

a third mirror surface located at an opposite end of the annular optical cavity.

36. A gas laser according to any of claims 31 - 35 and also comprising an output coupler.

09/830496

1/7

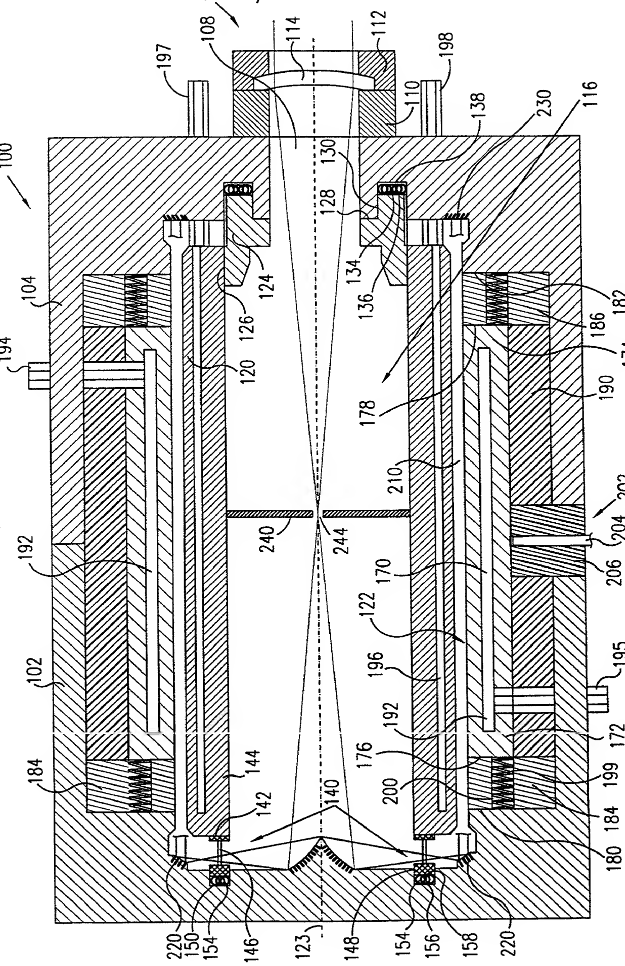


FIG. 1

09/830496

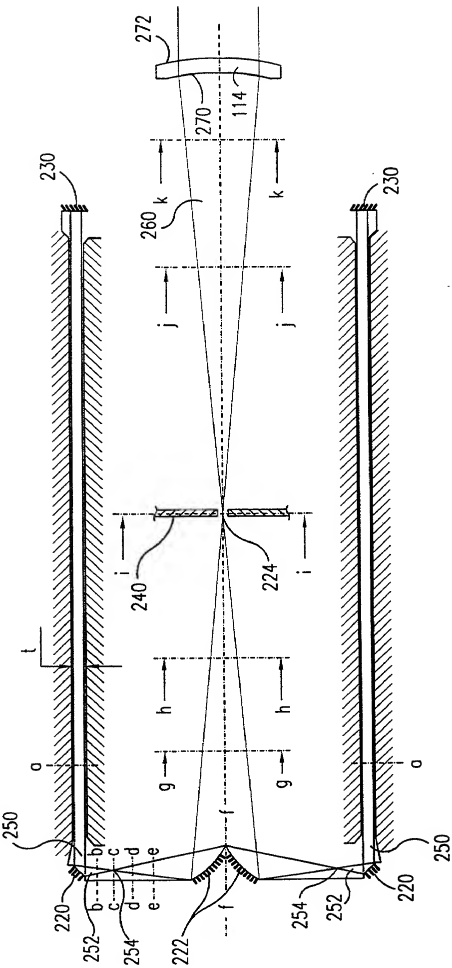


FIG. 2

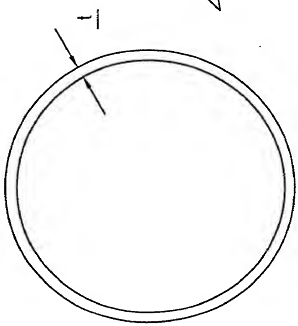


FIG. 3A

FIG. 3B

FIG. 3C

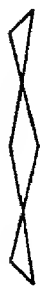


FIG. 3D

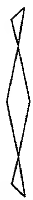


FIG. 3E

FIG. 3F

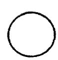


FIG. 3G

FIG. 3H

FIG. 3I

FIG. 3J

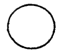


FIG. 3K

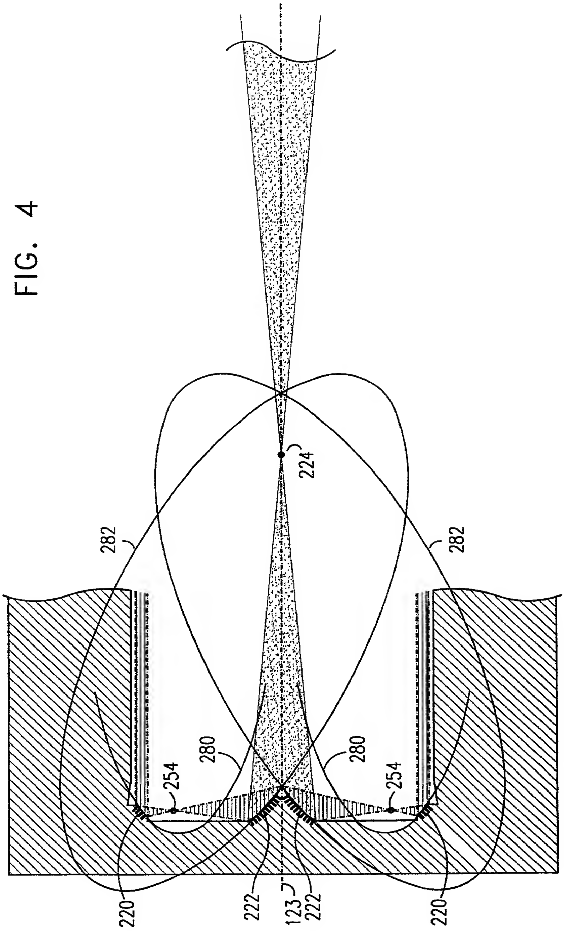


FIG. 4

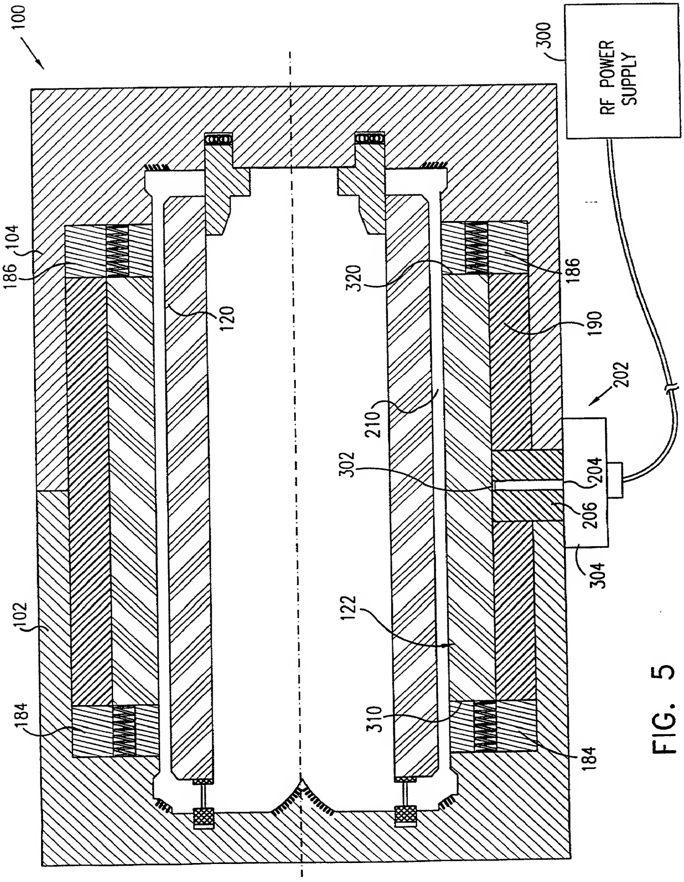

100
RF POWER SUPPLY
300
104
186
120
320
186
190
202
210
302
204
206
304
102
122
184
310
184

FIG. 5

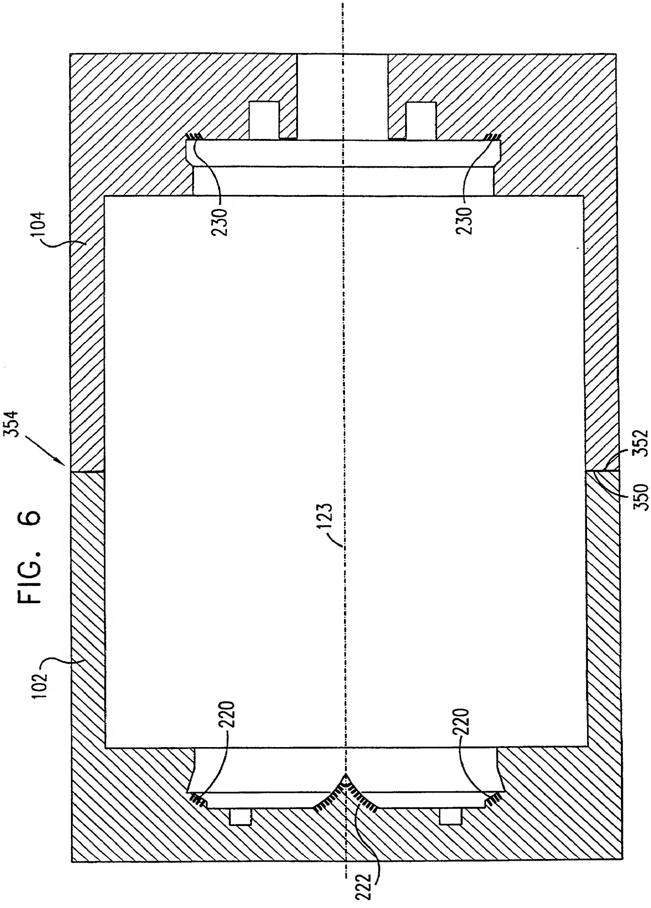
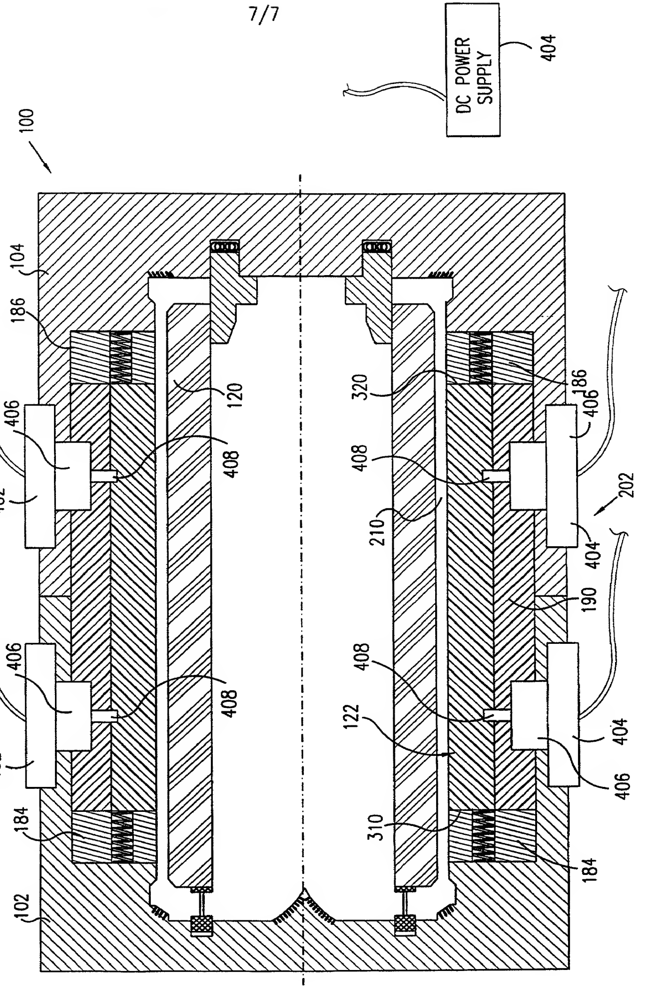


FIG. 6

09/830496

FIG. 7



Please type a plus sign (+) inside this box → +

PTO/SB/01 (03-01)
Approved for use through 10/31/2002. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted With Initial Filing OR ☒ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)) required)

Attorney Docket Number	020352-000100US
First Named Inventor	Oded Anner
COMPLETE IF KNOWN	
Application Number	09/830,496
Filing Date	April 26, 2001
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

GAS LASER

(Title of the Invention)

the specification of which

☐ is attached hereto

OR

☒ was filed on (MM/DD/YYYY) 04/26/01 as United States Application Number or PCT International

Application Number ____ and was amended on (MM/DD/YYYY) ____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
PCT/IL99/00566	PCT	26 October 1999	☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

DECLARATION — Utility or Design Patent Application

Direct all correspondence to:	☒ Customer Number or Bar Code Label	20350	OR ☐ Correspondence address below

Name

Address

Address

City	State	ZIP

Country	Telephone	Fax

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

NAME OF SOLE OR FIRST INVENTOR: ☐ A petition has been filed for this unsigned inventor

1-0

Oded Given Name (first and middle [if any])	Anner Family Name or Surname

Inventor's Signature X	Date 17/6/01

Residence: City	State	Country	Citizenship
KFAR SAVA ILX		ISRAEL	ISRALI

Mailing Address: 9/5 NAHLIELI St.

City	State	ZIP	COUNTRY
KFAR SAVA			ISRAEL

NAME OF SECOND INVENTOR: ☐ A petition has been filed for this unsigned inventor

2-0

Shlomo Given Name (first and middle [if any])	Turgeman Family Name or Surname

Inventor's Signature X	Date X 17/6/01

Residence: City	State	Country	Citizenship
RISHON Le ZION	IL X ISRAEL	ISRAEL	ISRAELI

Mailing Address: 32 HATIZMORet St.

City	State	ZIP	COUNTRY
RISHON LeZION			ISRAEL

☒ Additional inventors are being named on the 1 supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

DECLARATION

ADDITIONAL INVENTOR(S)
Supplemental Sheet
Page 3 of 3

3 D

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any]) Haim	Family Name or Surname Mukatel		
Inventor's Signature X			Date X 17/6/01
Residence: City NEZ-ZIONA	State ISRAEL	Country	Citizenship ISRAELY
Mailing Address			
Mailing Address 4 HARGAMAN St.			
City NES-ZIONA	State ISRAEL	ZIP 70400	Country ISRAEL

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])	Family Name or Surname		
Inventor's Signature			Date
Residence: City	State	Country	Citizenship
Mailing Address			
Mailing Address			
City	State	ZIP	Country

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])	Family Name or Surname		
Inventor's Signature			Date
Residence: City	State	Country	Citizenship
Mailing Address			
Mailing Address			
City	State	ZIP	Country

DE 7041819 v1